



# SPACE STATION™

## SST-282



## SERVICE MANUAL

SERIAL NUMBER:

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# **SPACE STATION<sup>TM</sup>**

## **SST-282**

• SERVICE MANUAL

### PROPRIETARY TECHNOLOGY

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**THERE ARE HAZARDOUS VOLTAGES PRESENT IN THE SPACE  
STATION SST-282 WHEN IT IS CONNECTED TO THE AC POWER  
LINE, EVEN WHEN THE POWER SWITCH IS "OFF". DO NOT DO  
ANY DISASSEMBLING, COMPONENT REMOVAL, OR PROBING  
INSIDE THE UNIT WHILE IT IS PLUGGED INTO THE AC POWER LINE.**

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## SPACE STATION SST-282 SERVICE MANUAL

### I. GENERAL DESCRIPTION OF OPERATION

The mono input signal from the external source goes through signal processing on the analog module (ANA-1), and then to the ADA-1 module, where it is converted to digital form. The 11-bit PCM code is stored in memory and recalled at later times to perform reverberation signal processing. There are 24 taps that read out of memory and are reconstructed by the ADA-1 module. The taps are then routed back to ANA-1.

The basic memory time of the SPACE STATION SST-282 is 256mS, while the reverberation decay time brought about by feeding signals back can be extended up to 3.5 seconds.

The sampling rate of the SPACE STATION SST-282 is 16kHz. Timing circuits on the Mother board (MOM-1) mastermind the sequencing of operations by dividing the sampling period, 62.5uS, into 256 subintervals, each called a "bit time" (BT). For each BT, the timing generation circuit specifies the state of each of a number of command signals; these are called the timing signals. They go off to the different modules and portions of MOM-1, to insure that operations take place at the right time, and in sequence. Other circuits on MOM-1 and on the address module (ADS-1) compute the memory addresses for write and read.

Additional circuits on MOM-1 allow the user to set the delay time of an echo tap, from 1 to 255mS, with a pot and its associated 8-bit A to D converter.

### II. OPERATION OF THE MODULES

#### II. A. The Analog Module (ANA-1)

II. A. 1. Operation of ANA-1: The input signal from the XLR Connector Pins 2 and 3 comes in differential form to U1, a differential input op amp, with gain of 1. The signal emerging from U1 goes through a potentiometer which provides attenuation, and then through another gain stage (U2), which has a gain of about 4. The output of U2 is called the "Direct Signal" and splits off and goes in two different directions.

One path takes the Direct signal through the Direct potentiometer where it emerges and is fed into the output summing amplifiers U10 and U11. In this way, the Direct signal goes straight through to the output of the unit, appearing in both channels as a mono center image.

The other path of the Direct signal takes it through one portion of U12, where it is subjected to a high frequency boost. The signal is then routed through another section of U12 (with a gain of 0.5), which acts as a mixing amplifier. Emerging from the mixing amplifier, the signal goes through a low-pass filter (LPF-1 on the schematic) composed of op amps U3 and U4. This is a steep cut-off filter with about 50dB attenuation in the stopband.

After coming out of the filter, the signal is given a gain of 2 by another section of U2, and then goes through adjustable low and high frequency equalizers. In the mixing stage (U12), a feedback signal either from the reverb taps or the echo tap can be added to the Direct signal. The amount of feedback appearing in addition to the Direct signal is controlled by the potentiometer RV9, "Reverb/Echo Feedback" on the front panel.

R1 - 15, the reverb tap feedback signal, is fed through a fixed equalizer, first a low frequency attenuation stage and then a high frequency attenuation stage.

Proceeding through section A of RV9, the reverb signal, if it is selected by the push-button switch S2, passes into R25, where it is mixed with the Direct signal in the mixing stage U12. Alternately, switch 2 can be set to the Echo position, where the single tap echo will be fed into the stage U12 through resistor R26.

The output of U2, pin 14, becomes a signal called AIN, which goes off to ADA-1 via J6, a ribbon connector cable. On ADA-1 the signal AIN is fed into a sample-and-hold, and then into the analog to digital converter. The audition delay taps that are reconstructed on ADA-1 then come back to ANA-1.

On ANA-1, each of these audition delay signals is brought, through a capacitor, into a section of a dual potentiometer, pots RV5 through RV8. The outputs of these 4 pots are mixed in op amp mixer U9, then fed through low-pass filters 2 and 3, identical to LPF-1. Emerging from the low-pass filters 2 and 3, these audition delay signals go through switch 1, the "Dry/Mixed" switch, where, with the switch in the Mixed position, they are enabled to pass into the output mixing stages U10 and U11.

II. A. 2. Special notes for troubleshooting ANA-1: The only really critical component in the low-pass filters is the operational amplifier. We have found the Motorola 4741 or the Exar XR4212's to be the best types to use in these circuits. Some op amps, such as the Texas Instruments BiFET series, will produce high frequency oscillation. Consult the factory for replacement parts for U3 - U8. If a frequency response problem is found, it should be possible to isolate it, either to the input circuitry common to all the audition delay taps, or to one of the output LPF's. Then comparisons among the three different filters should make it easy to find a bad component. (See IV. D. Basic Troubleshooting: Step-by-Step, point #4.)

## II. B. MOM-1: Timing Generation

The basic timing generation circuits are located in the rear center section of MOM-1. A crystal oscillator operating at 8.192MHz provides the basic clock signal in the machine. This is divided in half by U25 (a flip-flop), giving a clock signal about every 244 nanoseconds. The clock signal feeds a pair of cascaded 4-bit up counters, LS163's, U16 and U17. The 8-bit output of this counter constitutes an address for the timing PROM, U15. The timing signals shown in the timing diagram (see VI. B. ) are generated by the outputs of the timing PROM directly. These four signals are passed through U14, which is a quad D flip-flop with enable. (See V. #7. Scope Photo of Crystal.)

U24 is enabled only during read operations, whereas U23 is enabled only during the write period of the machine. Thus, signals  $\bar{E}$ , IB5, CP, and  $\bar{S}$  are only active during the period when ISH is high, and the signals DMS, RCLK, MCLK, and MCL are active only when ISH is low, during the read period of the overall timing cycle.

## II. C. The Analog to Digital Conversion Module (ADA-1)

II. C. 1. Operation of ADA-1: During BT's 0 - 49, ADA-1 performs an analog to digital conversion. It makes use of timing signals coming from MOM-1, signals E, ISH, and IB5. The analog input signal AIN is fed into a sample-and-hold circuit, U5, which is controlled by an inverted version of ISH. When the control signal for U5,  $\bar{T}ISH$ , goes low, U5 goes into the hold mode, and a steady output is maintained that can be used by the A to D converter. This output signal (at pin 5) is fed through a resistor, R15, into the comparator U6.



The A to D process is controlled by an SAR, U21, on MOM-1.

After the sign bit has been determined, the next test is C2, followed by C1, and then the 8 tests, B7 through B0. By the end of these 11 tests, the input conversion is complete.

The pedestal or exponent value comes from DAC U3, and the value along the chord (mantissa) comes from DAC U2. U3 is simply used as a multiplying current source, and its current is controlled by the resistors R6, R7, and R8. In the lowest range, U3 is turned completely off. The current ranges that U2 spans for each chord are determined by resistors R1 - R4, which control its reference input.

The currents from the 2 DAC's are combined and steered through a CMOS switch, a 4053, which has one section controlled by the sign, and another section controlled by  $\overline{EH}$ . During the A to D period discussed so far, the current is steered into U6, to perform the A to D conversion. At the end of this period, while ISH is still high, the converted 11-bit signal is written into memory.

Now begins a period (the remaining 195 BT's) in which 24 signals are read from memory, fed into the same D to A converter that was used for A to D, and reconstructed into analog signals, one by one.

The output of U7/pin 6 is a significant test point in the SPACE STATION. In the time sequence on U7/pin 6, you can see 24 different taps beginning when ISH is low. Looking at this signal synchronized to the sampling time of the SPACE STATION, you'll see 24 different slots, each with an analog signal in it (see V. #1). This signal from U7/pin 6 is a time-multiplexed signal containing 24 different audio signals that we would like to reconstruct. They are reconstructed with the aid of U10, U11, and U12, which are demultiplexers, CMOS analog switches that will each steer the signal to one of 8 output locations. They are further demultiplexed by the signals DMSH1 - DMSH3.

The power supply voltages for the CMOS switches are derived from a couple of Zener diodes, D9 and D10, and associated resistors and capacitors, from  $\pm 15$  volt supplies.

Another interesting test point is comparator U6/pins 2 and 3, where, during the early portion of the frame (that is BT's 0 - 50), the A to D operation and its successive approximation steps can be observed. At pin 3, the successive approximation operation of negative input signals can be seen with a wiffle tree converging upon the full range of negative input signal values. At pin 2, the

wiffle tree can be seen always converging to the zero base line, as currents are compared for the positive input signals. (See V. #2 and #3.)

When observing sampled signals, A to D, or D to A operations, it's important to synchronize the scope with an external trigger signal, ISH, which is available as a test point on the Mother board (one probe point for ISH is R14 on MOM-1). By observing and synchronizing the scope to ISH, you can determine the portion of the frame during which A to D and write operations are being done (that is, when ISH is high), and the portion (when ISH is low) when D to A operations are performed. It's always valuable to use ISH as a reference and trigger during scope examination of signals.

II. C. 2. Selection of pedestal DAC, U3: This DAC has the more mundane job to perform of the 2 DAC's in the SPACE STATION, yet it is a critical one because it is asked to operate with zero output current when the reference is shut off. Not all DAC-08's will do this. Factory substitutes provided will be O.K. to use in this position. However, if it is necessary to double check this feature in the field, here's how to do it:

- a. Using the external sync input of your oscilloscope, synchronize the scope to an audio input source of about 40Hz which is also connected to the SPACE STATION input connector.
- b. On MOM-1, place a jumper across Jumper 2. This is a position in an 8-bit socket on MOM-1; in the right rear center of the machine. This sets all the delay times to zero.
- c. Turn the front panel control "Reverb/Echo Feedback" to full counter-clockwise.
- d. Connect an oscilloscope to U7/pin 6 on ADA-1.
- e. Increase the scope sensitivity to 1, 2, or 5 millivolts/division, depending upon the scope, and reduce the audio input signal until the waveform just about fills the scope screen. The scope should be DC coupled.

You'll see a noisy step approximation of a sine wave and a faint horizontal line crossing near the center of the scope face. If there is a problem from the converter, U3, you'll see an extra large step in the waveform approaching and going away from the horizontal base line. If you have any problem, get the replacement DAC from the factory.

## II. D. MOM-1 Memory Circuits

By the end of the A to D conversion (U21), the successive approximation register (SAR) on MOM-1 holds the nearest 11-bit code

representing the input signal. Next, a sequence of commands by signals  $\overline{\text{CAS}}$ ,  $\overline{\text{RAS}}$ , R, and  $\overline{\text{E}}$  will write the 11-bit code into memory (see V. #5).

Most of the memory address circuitry is found on the ADS-1 module, but circuitry on MOM-1 provides the delay offset values. This circuitry includes PROM U35 and related circuitry U33 and U34. The front panel push-button switches for the "Audition Delay" and "Reverb" programs change addresses to the delay PROM U35, causing timing signals RC0 - RC2 to access different portions of the memory to recall the correct delay values. These 8-bit delay values (DA7 - DA0) go back across MOM-1 to the rear of the machine, and into ADS-1, where they are used to determine the amount of delay time for each tap.

The read counter, which develops signals RC0 - RC5, is also on MOM-1, and is part of the timing generation necessary to perform the address operations. This is a simple 5-bit counter, which is reset at the end of each frame, and then counts from 0 to 24 binary, providing a basic address for each of the 24 taps. These are used to address portions of the delay PROM, as already seen, and are used on the ADA-1 by each demultiplexer. The read counter is advanced by the clock signal, Read Counter Clock (RCCK), which comes from the timing circuit, and is detailed on the timing diagram (see VI. B.). Each clock pulse causes the counter to increment by 1.

## II. E. The Address Module (ADS-1)

II. E. 1. Operation of ADS-1: This module computes and sends one write address and 24 read addresses to MOM-1 for use by the random access memory (RAM). The output of ADS-1 is the signals AE0 - AE5, a 6-bit wide multiplexed row and column address for the RAM.

At the end of the A to D operation, while EZD is still 1, we steer the write address through the multiplexer in two 6-bit bytes. The write address is simply the output of the write counter, U13, U22, and U23. This is a 12-bit down counter, which counts from all ones down to all zeros, then flops into all ones and continuously repeats.

II. E. 2. Verifying correct modulation: Connect a low frequency (about 50Hz) audio input signal to the SPACE STATION and adjust it for a little below limiting. Turn the "Reverb/Echo Feedback" potentiometer on the front panel to 0. Connect a dual trace scope with external sync capability, and use the audio oscillator feeding the SPACE STATION to also trigger the scope, so it is synchron-

ized to the 50Hz signal. Adjust the sweep speed to 2mS/division and adjust the vertical sensitivity of each input to about 5 volts/division. Adjust the base lines of inputs 1 and 2 so that the two waveforms will fit on the screen.

With the cover off the SPACE STATION and the unit facing you, find the upper right corner of ADA-1, and locate the resistor networks RN4 and RN5. Refer to the drawing below, showing the reverb tap assignments to the different pads of these two resistor networks, and the one discrete resistor. Begin by putting the Channel 1 probe on R1, and the Channel 2 probe on R2. You should have an oscilloscope display of two audio waveforms, one drifting first to the right while the other drifts to the left, and then visa versa.

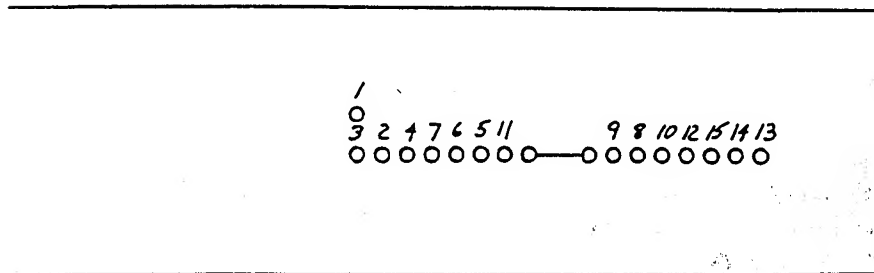


Figure: Reverberation Tap Assignments.  
ADA-1 PC Board, upper right corner,  
viewed from solder side of board.

Next, you will look at 6 different pairs of signals similar to the one that you have just seen. After R1 and R2, continue to pairs R3 and R4, R5 and R6, etc. For each pair, there should be an opposing drift pattern -- that is, while the upper one is drifting right, the lower one should be drifting left. Although there will be little interruptions, or glitches, in the waveforms, they should drift smoothly with no major jumps. Each waveform should reach the end of its left-to-right drift at the same time that its companion has drifted to the extreme of the opposite direction, and they should change directions simultaneously. (See V. #8.)

## II. F. MOM-1 Special Circuitry

II. F. 1. Computation of echo delay value: MOM-1 circuits U36, U37, U38, U39, and U40 are used to compute the echo delay value. The echo tap is a special tap fed back to create very simple effects, from "hello, hello, hello" echoes to highly resonant filters. What we need from this circuitry is an 8-bit word to put

on the DA lines to determine the delay time of this particular tap. To this end, a 5-volt signal is varied by the front panel-mounted pot RV1, on MOM-1, buffered by U40 and fed into the A to D converter. The A to D converter comprises a comparator (U39), a DAC (U38), and a successive approximation register (U37). These three IC's are controlled by the clock signal CP and a negated start pulse which comes through U35, under the control of the ES signal. When the front panel "Echo/Delay" push-to-set button is depressed, the start pulse is allowed through and conversion can take place. The output of the successive approximation register is placed on the line by a tri-state buffer, U36. The output from U36 is enabled only when the signal  $\overline{EC}$  goes low. At all other times, the delay PROM itself, U35, is on the line.

II. F. 2. Peak level indicator: Another set of circuits on MOM-1 is used for the peak level indicator. Four LED's are driven by a 7406, which is controlled by one-shots. The 4 one-shots examine the binary value of the recently digitalized audio signal. The limit, or zero, indicator will be on if chords C2 and C1 are both 1 (i.e., we're on the top most chord of the converter), and if quite a number of the lower order bits are on. The -6 LED looks only to see if chords C1 and C2 are high. The -15 LED looks similarly to see only that chord C1 is high. And, for the -30 LED, we look to see that both chords C2 and C1 are low, indicating that we are on the bottom chord, which covers the range of -infinity to -30dB. The one-shots are timed with a 47K resistor network and a 4.7uF capacitor, so that once triggered they will stay on for 100mS, giving a peak/hold display.

II. F. 3. Verifying performance with temporary DIP switch on MOM-1: There is other special circuitry on the MOM-1 module related to testing and verifying performance. An 8-pin socket is placed on MOM-1 in the right rear center, near the crystal, to the left of the power supply section. There is nothing in the socket when the machine is shipped from the factory. During test at the factory, an 8-pin DIP switch (4-SPST) may be inserted into the socket for test purposes. When all 4 DIP switches are open, the machine, of course, operates normally.

When Jumper 1 is closed, the modulation counter is forced to all zeros, so that all the AB signals will be 0. This is a test mode that disables modulation, and although the machine will not function properly as a reverberation system, some observations will be simpler.

Jumper 2 is nicknamed ZD, for zero delay. Closing that jumper forces zero delay on all taps by forcing the RAM address multiplexer control signal EZD to 1, all the time. With EZD at 1, the address multiplexer on ADS-1 will always steer the write counters to the RAM's, so the write counter address which was

just used for writing will be used again for all 24 read operations as well. This effectively isolates all the adders and all the delay address preparation circuitry, including the modulation counter, so that performance of the machine can be observed without any of that circuit influencing the operations.

Jumper 3 will bypass memory altogether by forcing the signal EMB to 1. EMB is used by a multiplexer feeding the DAC. Referring to the MOM-1 schematic on which the memory circuitry is shown, multiplexers U19, U20, and U22 are controlled by signal EMB. When EMB is 1 in normal operation, that is, during the encode period, the DAC is fed from the successive approximation register connected to the RAM inputs. When EMB is low, the DAC is fed from the RAM outputs, and receives the 24 different values of the stored signal. By forcing EMB to 1, the DAC always receives the output of U21. In this way, the reconstructed audio signal should be identical to the value that the A to D came up with during its conversion. Memory is not involved at all, neither is the delay address circuitry, or the modulation circuitry.

Jumper 2 and Jumper 3 are especially useful in debugging questionable conversion problems. If there is distortion or glitching in a reconstructed audio waveform, and it goes away when Jumper 2 is closed, then we can suspect something to do with the RAM addressing, or a bad RAM itself. If it remains when we close Jumper 2, we can next close Jumper 3, bypassing the memory altogether. If the problem still remains, we can be fairly confident that it is a difficulty in conversion, either A to D, or D to A. If the problem goes away with both Jumpers 2 and 3 closed, then we can suspect one or more of the 11 RAM's or timing circuits.

The last jumper, Jumper 4, is one you will never need to use. Jumper 4 resets all the counters in the machine by forcing the signal  $\overline{\text{INT}}$  low. This signal is forced low during turn-on, so that the machine wakes with all the counters reset to a known state. This is intended to aid manufacturing check-out. Of course, Jumper 4 must be open or the whole unit will be inoperative.

### III. POWER SUPPLY CIRCUITRY

Refer to the MOM-1 schematic showing the power supplies. The universal power connector is brought through a push-button switch on the front panel which switches both sides of the line. One side of the line is fused, and should have a 3/8 amp fuse

(.375) for operations with 230 volts, and 3/4 amp (.75) for 115- or 100-volt operation. These are fast-blow, type 3AG, fuses. A slide switch on the bottom of MOM-1 selects transformer operation with the windings in series (230 volts) or in parallel (115 volts). A special transformer, part #470-0254, is available for operation in countries whose line voltage is normally 100 volts, such as Japan. But, in fact, the regular transformer unit will operate satisfactorily down to about 90 volts.

There are 3 regulator power supply voltages derived in the right rear corner of the SPACE STATION, with TO-220 style regulators heat sunk to the chassis. The 5-volt supply is intended to provide a nominal 1.2 amperes, and uses a 7805 or LM340-5 IC voltage regulator. This is fused by a 3-amp fuse, and the regulator is protected by diodes D6 and D7, against various kinds of malfunctions that can upset regulators.

Circuitry using SCR1, R13, C69, and D8, at the output of the regulator provides a crowbar protection circuit. In the event of a rise in the nominal +5 volt output of this power supply, to 6.2 volts or so, the Zener turns on and forces a current down through R13, which turns on the SCR. This would occur, for example, if the regulator were shorted, failed with a short circuit, or someone dropped a screwdriver in the unit and that connected +5 to +15, or +5 to the raw power supply voltage coming out of D9 and D10, and started to force the +5 volt line high. If the +5V line goes high, it will destroy TTL circuits, so the crowbar goes into operation if the line rises above about 6 volts and provides a strong short circuit clamp between the output of the regulator and ground. This should blow fuse F1, and clear the condition that put the unusually high voltage on the output. If you encounter a machine in which F1 has been blown, proceed very carefully.

The +15 and -15 volt power supplies are straightforward 3-terminal regulators, with the same sort of diode protection as already discussed. The raw DC voltage for the +15 supply, +22, is taken off separately and fed to the RAM array, where another 3-terminal regulator derives a +12 volt supply. The +12 volt supply is used only by the RAM's and is isolated by this regulator to keep noise out of the rest of the machine. A Zener diode and R15 on MOM-1 (again, near the RAM array) derive a -5 substrate bias for the RAM array. This is a very low current supply with heavy capacitor bypass. It's interesting to note here that if the -5 supply is somehow lost, and reverts to ground while +12 is connected, the RAM's will be destroyed. So, be careful.

## IV. TROUBLESHOOTING

### IV. A. Test and Troubleshooting Equipment

The minimum test equipment needed is a good dual-trace scope (25MHz or, preferably, better), with an external trigger. Also helpful is a low distortion audio oscillator, a distortion analyser, and an audio volt meter. A vacuum tube volt meter, VOM or DVM, can also be helpful. A second SPACE STATION working normally is obviously also a valuable tool, used as a reference, and as a source of modules to swap into the defective unit to help isolate the problem.

### IV. B. Disassembling Instructions

IV. B. 1. Access to the circuitry - removing top and bottom covers: Removal of the top and bottom covers of the SPACE STATION is a fairly obvious procedure; simply remove the 8 screws around the perimeter of each cover. Once the covers are removed, any circuit point in the machine can be probed, either from the bottom of the Mother board or from the top sides of the three other modules, which are visible from the top view. If you need to replace an IC on the area of MOM-1 underneath ANA-1, it can generally be reached without any further disassembly by removing ADA-1 and using an inspection or a dentist's mirror to help see underneath ANA-1, and a screwdriver or tweezers to pry the IC out of its socket.

IV. B. 2. Removing ANA-1: In the rare instance in which you have to remove ANA-1, either to get at something underneath it or to replace a passive component on the module itself, follow these steps:

- a. With a very thin-bladed knife, gently pry the top covers off the nine knobs on ANA-1. These are the colored inserts at the end of the knobs.
- b. Then loosen the nuts or screws holding the knobs in place, remove the knobs and the nuts, holding the potentiometers to the front panel.
- c. Next, find and remove the two screws that anchor the left and right rear edges of ANA-1 to brackets on the side of the panel. When you remove them, be sure to get the star washer out, too.
- d. Unplug the DIP cable that goes to ADA-1, and remove ADA-1.
- e. Now unplug the 3 shielded wires coming from the connectors that plug into ANA-1.
- f. Slide ANA-1 to the rear and lift it up and out of the machine.



This gives you access to everything underneath and, of course, ANA-1 is out so you can work on it.

When reinstalling ANA-1, tighten up the nuts around the 9 potentiometers before installing the screws that hold the left and right rear corners in place. This reduces possible stress on the potentiometers.

IV. B. 3. Removing components with multiple leads: All the modules in the SPACE STATION have plated-through holes. When removing a component, use a vacuum solder remover to completely remove the solder from the hole, so that the component lead is free and wiggles loose, before trying to pull the lead out of the hole. Since all the IC's are socketed, there are very few components with multiple leads that would have to be removed during servicing. But if you have to remove one of the connectors, one of the potentiometers, or one of the push-button switch sections, be very careful. Thoroughly desolder and individually loosen each lead before trying to remove the whole component. If you really get stuck, try to get a pair of diagonal cutters in between the component and the top side of the board, and cut the component free, one lead at a time. Do anything you can to avoid damaging the board.

IV. B. 4. Procedure for removing or replacing IC's: When replacing an IC or removing one from a socket, shut the power off to the SPACE STATION. Failure to do so could damage the IC itself, or another IC associated with it, or even the power supply. Another handling precaution applies especially to the CMOS circuits, the 4051, 4052, and 4053. These are highly susceptible to static electric problems and should be kept in conductive material like tin foil until use.

Also, when inserting an IC into a socket, be careful that all pins are straight, that they engage the correct hole on the socket, and that each lead seats properly. If undue force is needed to seat the IC in the socket, you are probably bending a lead over and not getting it into its hole. Use a real IC extractor to pull IC's straight out and thus keep all the pins straight. An inspection or dental mirror will help you sight between the IC and socket to check for bent-over leads.

#### IV. C. Intermittent Problems

The most difficult problems to track down are those that are intermittent, that appear only when the unit is cold, only when the unit is hot, only when it is hit occasionally, or, seemingly,

at random. You must be very patient with this kind of machine. If you are quite sure that it has been intermittent, then get it on the bench and try it out. If it seems to work normally, let it cool down, try again, heat it up, try it again, hit it, bang it, etc., until, however you manage to do it, you get the problem to appear and remain. Once the intermittent machine is actually operating in the failed mode, be very gentle with it so that you keep it broken until you find the problem.

If you haven't already, carefully remove the top cover and start probing around with the scope. It is hoped that the failure mode that you can hear by listening to the machine will tell you something about where the problem is. As you proceed in normal troubleshooting from this point, be very, very careful that you don't disturb the machine into working normally again. Use the probe very gently to look for intermittent connectors, where a signal appears on one side of the connector and not on the other. Look for illegal logic levels, non-normal power supply voltages, etc.

#### IV. D. Basic Troubleshooting: Step-by-Step

In some ways, the SPACE STATION is a very simple machine. Most of its functions are done sequentially and independent of external conditions. The machine cranks through the 256 BT timing cycle over and over again, and most of the logic and analog circuits operate in a manner simply determined by the state. That is, the timing circuitry gives out a series of commands which the machine follows. The only exceptions, in which the machine interacts with itself and with data, occur during the A to D conversion (when the successive approximation routine must use the signal from the comparator to determine how to proceed through the conversion steps, and during the operation of the modulation counter, already described, on ADS-1. Those two circuits are the hardest in the SPACE STATION to troubleshoot because they are dependent upon previous states of the machine in a feedback manner.

What follows is an outline of the logical order in which to proceed when troubleshooting the SPACE STATION.

IV. D. 1. Visual check: Look in the unit for things like an IC that has come loose or fallen out. Look for something that is charred or burned. Look for a connector, such as a ribbon cable that has jiggled loose. Look for a piece of wire or a solder blob lying down in the machine.

IV. D. 2. Power supply check: If nothing shows up visually, check the power supply voltages: +5, +15, -15, -5, +12 on MOM-1; +7, -8, +5 (at U21/pin 2) on ADA-1. If possible, use a DC coupled oscilloscope for this check so that you could also detect ripple, which would be the result of regulator failure.

IV. D. 3. Timing signals: Start with the MOM-1, Sheet 2 schematic, and verify all the timing signals shown on J2, J1, and J5. If they all match the signal indicated on the master timing diagram, then so far, so good. You have to use your imagination on some of the signals, like DMS1 - DMS3, which are derived from DMS, and are not shown on the master timing diagram. It's helpful when looking at timing signals to synchronize the machine externally to the ISH signal on MOM-1. Adjust the scope's variable sweep time control so that you have exactly one complete cycle of ISH beginning with the high portion to the left of the scope screen, and the low portion to the right. This gives you a stable reference with which to compare the signals you see to the ones in Section V. SCOPE PHOTOGRAPHS. Keep your eye out for illegal logic levels, also. This is a TTL logic based machine, with a 5-volt supply, so the high logic levels are above 2.4 and the low logic levels are below 0.8 (see IV. D. 5, below). Signals that spend any appreciable time in between those two states are suspect. When tracing a signal that goes to one of the edge connectors, to ADS-1 or ADA-1, make sure the signal passes through both parts of the connector. One can occasionally get an intermittent connector. Probe very gently at both the male pin from MOM-1 and the female connector portion actually up on the other module. (See V. SCOPE PHOTOGRAPHS, #4, for a view of the DMS signals.)

IV. D. 4. Analog signals - emphasis on LPF's: If all the power supply voltages are O.K., and all the timing signals check out, then it is time to dig deeper into the circuits involved by normal signal tracing. Analog signal problems on the ANA-1 should respond to straightforward servicing techniques. These are basically simple op amp circuits. The low-pass, LPF-1, -2, and -3, are a little tricky, but there are three of them. A useful trick with the LPF's is to temporarily get them all responding to the same input, and then to compare overall performance mode voltages. To do this, remove U9 and U12 on ANA-1, and simultaneously clip-lead a low-impedance audio generator ( $\leq 600$  ohms) into the left end (facing the front panel) of R101, R201, and R301. Power down before removing or replacing IC's.

IV. D. 5. Logic signals: When troubleshooting logic signals, finding a signal that doesn't lie in the proper logic levels (below 0.8 and then making a transition to greater than 2.4 volts - see IV. D. 3. above) means you may have a problem with the logic signal source somewhere along the way, perhaps shorted or tied to another signal, or feeding a shorted IC input. Each signal has a source and perhaps more than one destination. The problem can be at either source or destination. Since all the IC's in the SPACE STATION are socketed, you can identify each destination for a signal and remove the IC's at each destination one at a time to see if the problem is due to a failed IC input. If the IC that sources the signal is suspected, look around to see if the same IC type is used elsewhere, and momentarily swap a circuit from another position into the suspect position to see if the signal is then normal.

IV. D. 6. ADS-1 problems: First, you must determine if the problem is likely to be on ADS-1. You can suspect ADS-1 if the delay time values are mixed up, if the audio waveform is subjected to skips and jumps in the audition delay taps or the reverb taps (especially if the problem is in one of those groups of taps, and not the other). Remember the jumpers on MOM-1. Short the Jumper 1, to disable the modulation counter, and see if the problem with the reverb taps disappears. If it does, then we can suspect the modulation circuitry. If the problem is also with audition taps, or with the audition delay taps only, then shorting Jumper 2 or Jumper 3 can help isolate the problem to an address computation, or to the RAM itself.

IV. D. 7. Basic tip - module swapping: If you have access to a second, normally operating SPACE STATION SST-282, it is sometimes helpful, if the MOM-1 circuits seem to be functioning properly in the problem machine, to swap an ADS-1, ANA-1, or ADA-1 module temporarily with the good unit. One hopes that this will help isolate the problem to one module. In that case, you can compare signals in the two units to isolate the problem further.

#### IV. E. Routine Calibration

There is only one adjustment to be made in the SPACE STATION. A small potentiometer on ADA-1, symbol RV1 on the schematic, is used to balance the gain of the op amp U7 for positive signals relative to its gain for negative signals. To adjust it properly, feed in a 400Hz tone and adjust for audio signal level just below the limit light flashing. Be sure that the "Reverb/Echo Feed-

back" control is turned completely down. Measure the distortion of the output of one of the taps -- that is, turn up, for example, Tap 1 and 2 "Mixer" control on the SPACE STATION, turning the other 4 "Mixer" control knobs all the way counter-clockwise. Measure the distortion and listen, if possible, to the distortion residual. Carefully turn RV1 for a minimum reading on the distortion meter and/or for hearing an audible null of the 2KHz harmonic in the monitor output of the distortion analyzer. This is a simple adjustment; just turn it for a null. The distortion on an average responding distortion analyzer should read between 0.07 and 0.1% distortion and noise. There are no other adjustments to make in the SPACE STATION. Things work or they don't.

#### IV. F. Running Design Changes

IV. F. 1. PROM at U15 on MOM-1: In the Spring of 1978, the timing PROM, U15 on MOM-1, was changed from revision 11/1 to 11/3. This corrected a potential for a very occasional race condition involving the signal MCKK, which was delayed by one BT in the Revision 11/3 PROM. There is no need to replace an 11/1 PROM with a later PROM if the machine is working normally, as virtually all of them did. Any problems were caught at the factory.

IV. F. 2. Mounting screws on power transformer: In the Fall of 1979, we discovered a problem with screws on the power transformer. The two mounting screws were loosening as wax used to impregnate the transformer softened and crept. That problem was solved by replacing the Keps nut with a lock nut, a splitlock washer, and two flat washers. Again, it's not necessary to make a change in the field, just check to make sure that those two screws are tight when the unit comes in.

IV. F. 3. Wiring of the output connector (XLR connector): Also in the Fall of 1979, the wiring of the XLR connector was changed so that the high side of the signal appears at Pin 3, not, as in earlier units, at Pin 2. Pin 2 is now grounded along with Pin 1 at each of the two output connectors. No change was made in the input wiring, although Pin 3, previously identified as the low side, is now identified as the high side. This makes the machine uniform with the majority of users, who use Pin 3 at the high side. It also maintains the correct phase for the direct signal passing through the machine. (When Pin 2 is used as the high side of the input, then the direct signal ends up out of phase.)

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IV. F. 4. Change of op amps at U2 on ANA-1: U2 on ANA-1, which had been a 4212 or 4741-type quad op amp, was changed in late Spring, 1980, to a TL074 or TL084 op amp, in response to an observation by a reviewer from Modern Recording that U2 could go into slew limit. This slew limit will never occur with ordinary audio signals. It will only occur if a reviewer subjects a unit to very high frequency, high amplitude, signals out of the pass band of the delay system. It's not a change that needs to be done in the field unless someone is determinedly interested in this kind of thing.

IV. F. 5. Change of PROM's at U15 and U35 on MOM-1: The PROM's used in the SPACE STATION for U15 (the Revision 11/3 timing PROM) and for U35 (12/1 delay PROM) on MOM-1 have generally been Texas Instruments 74S471 types. Some units used Monolithic Memory 6309 types. A few machines used Texas Instruments 74S472 PROM's. When the TI 74S472's were used in the U35 slot in early units, cuts had to be made to interchange the functions of Pins 16 and 15, so that Pin 16 was grounded and Pin 15 was connected to the EC signal. (Later this change was made on the MOM-1 PC artwork.) Once the etch cut has been made, either an S471 or an S472 part will work in the socket U35. Occasionally, in units built in 1979, PROM U15 on MOM-1 was an S472 type. Again, either type will work there.

IV. F. 6. Possible substitution at U11 and U12 on ADS-1: Another substitution that has been made at times is a 74S189 or 54S189 scratch pad memory on ADS-1 at U11 and U12. The design was based on a 74LS189, but this part has been hard to get. The various parts are completely interchangeable.

#### IV. G. Spare Parts

IV. G. 1. Obtaining replacement parts from the factory: Most of the components in the SPACE STATION should be obtainable locally. In addition, some dealers, especially overseas dealers, will have purchased spare parts kits from URSA MAJOR and should have even the hard-to-find parts on hand. If your dealer doesn't have a part, and you wish to buy parts directly from the factory, please be sure to furnish the following information: the serial number of your machine, the module on which the component appears (MOM-1, ADA-1, ANA-1, or ADS-1), a complete description (including part number) of the defective part, and, if possible, the proper URSA MAJOR part number from the lists (Section VI) in this manual. It would also be useful to us if you would describe any peculiar circumstances



attendant with the failure. As of this writing, we've had very few failures in the field in general, and very few failures of integrated circuits (only 4 or 5 IC's of all the machines in the field). There is no failure pattern, but we would like to know what you find if you have a problem with a unit.

IV. G. 2. Special note on ordering switches: When ordering switches, please identify whether the switch is a Centralab type, which can be recognize by a white plastic snap-on cover over the rear of the switch, or a Schadow type, which is completely sealed black plastic with a brown top cover.

A defective push-button in the large, 16-station switch assembly on MOM-1 can be replaced individually, especially if it's a Schadow type. If the defective push-button is a Schadow type, simply unbend the 4 tabs that are used to crimp it in place, thoroughly desolder the 6 or 12 leads, and then gradually, carefully, pry the individual section loose. Then you need only replace that section.

IV. G. 3. Emergency substitutions: There are some possibilities for emergency substitutions of parts that may be easy for you to obtain locally. Most of the logic IC's are from the 74LS series. They can be replaced with military versions (54LS), with equivalent LS versions from some other manufacturers, and, in some cases, with conventional 7400 series IC's. For example, a 74LS163 could probably be temporarily replaced with a 74163. As indicated elsewhere, the 4051 multiplexers on ADA-1 should be replaced only with Motorola 4051B types. On ANA-1, the 4741 quad op amps should be replaced only with Motorola types. On ADA-1, U3 (a DAC-08) is selected at URSA MAJOR to have zero output current when the reference current is switched to zero in the lowest signal range. Elsewhere we've discussed how to select that part. It should be replaced only with a similarly selected IC.

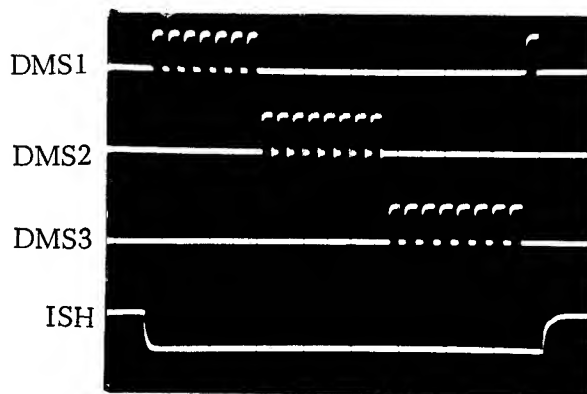
IV. G. 4. Passive components: With regard to the passive components, any of the resistors in the SPACE STATION could be obtained locally. A single in-line resistor network, such as those found on MOM-1 and ADA-1, can even be replaced with discrete resistors, if care is used in soldering a little assembly of 1/4 watt resistors together. Bypass capacitors are completely non-critical; the many 0.02's and 0.1's sprinkled around the machine can be replaced with an equivalent part. This is also true for the 4.7 and 22uF tantalum capacitors. In most instances, the bypassing is conservative enough so that if a capacitor were to fail, it could simply be removed.

IV. G. 5. Spare modules for troubleshooting: A few dealers may have spares of the three easily removeable modules, ANA-1, ADA-1, and ADS-1. These can be helpful during troubleshooting, or as a source of parts. In troubleshooting, the obvious advantage is that you can simply swap out an entire section of circuitry to see where the problem lies. If you have access to a second machine, and module swapping narrows the problem so that you recognize which module is not working properly, but you are unable to fix the unit, please contact URSA MAJOR by telephone, telex, or letter, and we'll arrange for swapping a replacement module.

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- 20



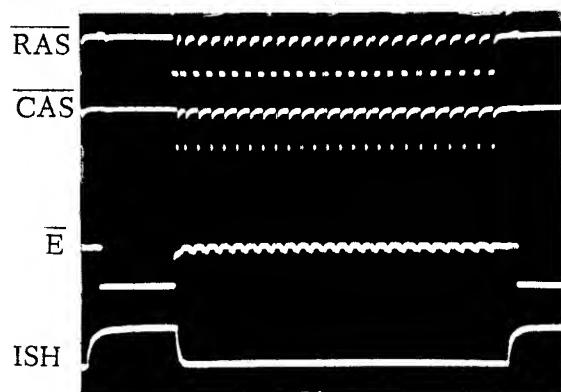
#### #4. DMS1 - DMS3 Signals

Probe Points: J5/pin 14 (ADA-1) - DMS1  
J5/pin 15 (ADA-1) - DMS2  
J5/pin 13 (ADA-1) - DMS3  
R14 (MOM-1) - ISH

Trigger Signal: ISH

Input Frequency, Input Level Display,  
and Panel Button Setting: NR

Scope Amplitude: 5V/div. each signal  
Scope Time Scale: 49uS/period of ISH



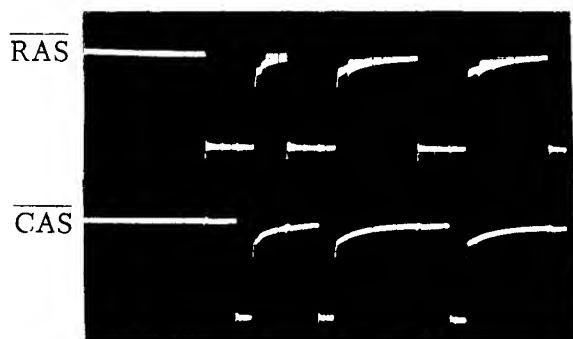
#### #5. Relationship of $\bar{RAS}$ , $\bar{CAS}$ , $\bar{E}$ , and ISH

Probe Points: U13/pin 4 (MOM-1) -  $\bar{RAS}$   
U13/pin 15 (MOM-1) -  $\bar{CAS}$   
U13/pin 3 (MOM-1) -  $\bar{E}$   
R14 (MOM-1) - ISH

Trigger Signal: ISH

Input Frequency, Input Level Display,  
and Panel Button Setting: NR

Scope Amplitude: 5V/div. each signal  
Scope Time Scale: 62.5uS/period of ISH



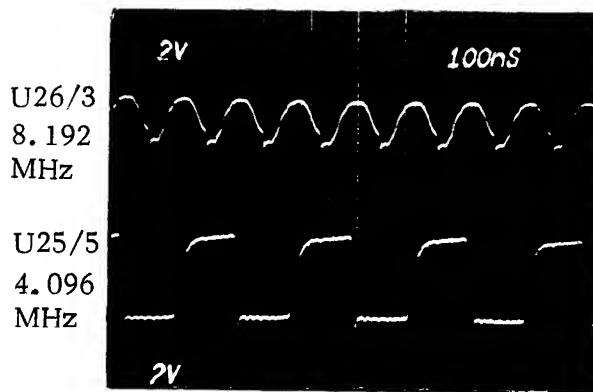
#### #6. Relationship of $\bar{RAS}$ and $\bar{CAS}$

Probe Points: U13/pin 4 (MOM-1) -  $\bar{RAS}$   
U13/pin 15 (MOM-1) -  $\bar{CAS}$

Trigger Signal: ISH at R14 (MOM-1)

Input Frequency, Input Level Display,  
and Panel Button Setting: NR

Scope Amplitude: 2V/div. each signal  
Scope Time Scale: = .75uS/div.



#### #7. Crystal

Probe Points: U26/pin 3 (MOM-1)

U25/pin 5 (MOM-1)

Trigger Signal: ISH at R14 (MOM-1)

Input Frequency: U26/pin 3 = 8.192MHz

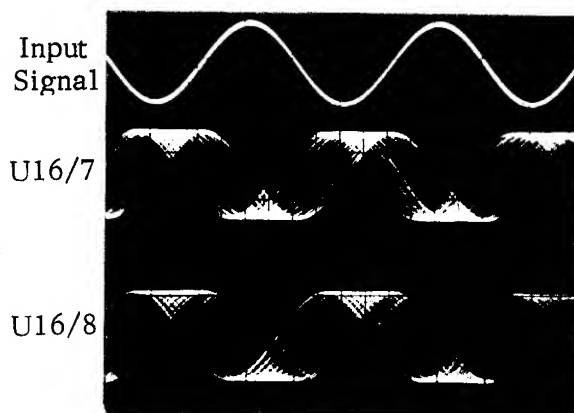
U26/pin 5 = 4.096MHz

Input Level Display, Panel Button

Setting: NR

Scope Amplitude: 2V/div. each signal

Scope Time Scale: 100ns/div.



#### #8. Modulated Output Taps

Probe Points: Input Signal

U16/pin 7 (ADA-1)

U16/pin 8 (ADA-1)

Trigger Signal: Input Signal

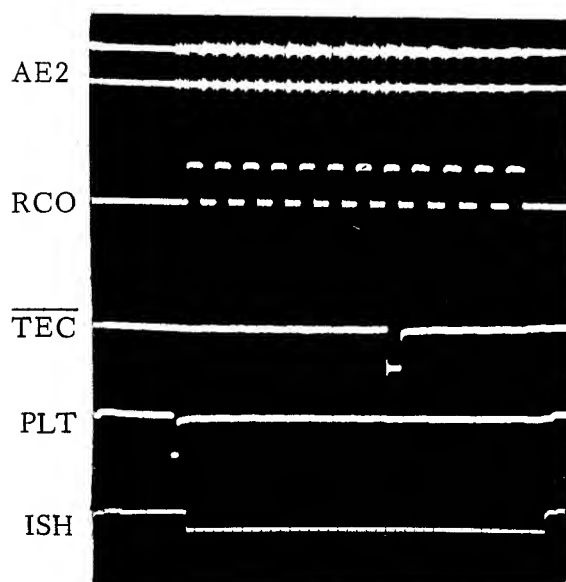
Input Frequency: 50Hz

Input Level Display: Not quite lighting  
Red LED

Panel Button Setting: NR

Scope Amplitude: 2V/div. each signal

Scope Time Scale: 5ms/div.



#### #9. Relationship of AE2, RCO, $\overline{\text{TEC}}$ , PLT, and ISH

Probe Points: J1/pin 6 (ADS-1) - AE2

J2/pin 15 (ADS-1) - RCO

J3/pin 1 (ADS-1) -  $\overline{\text{TEC}}$

U27/pin 11 (MOM-1) - PLT

R14 (MOM-1) - ISH

Trigger Signal: ISH

Input Frequency, Input Level Display,  
and Panel Button Setting: NR

Scope Amplitude: 5V/div. each signal

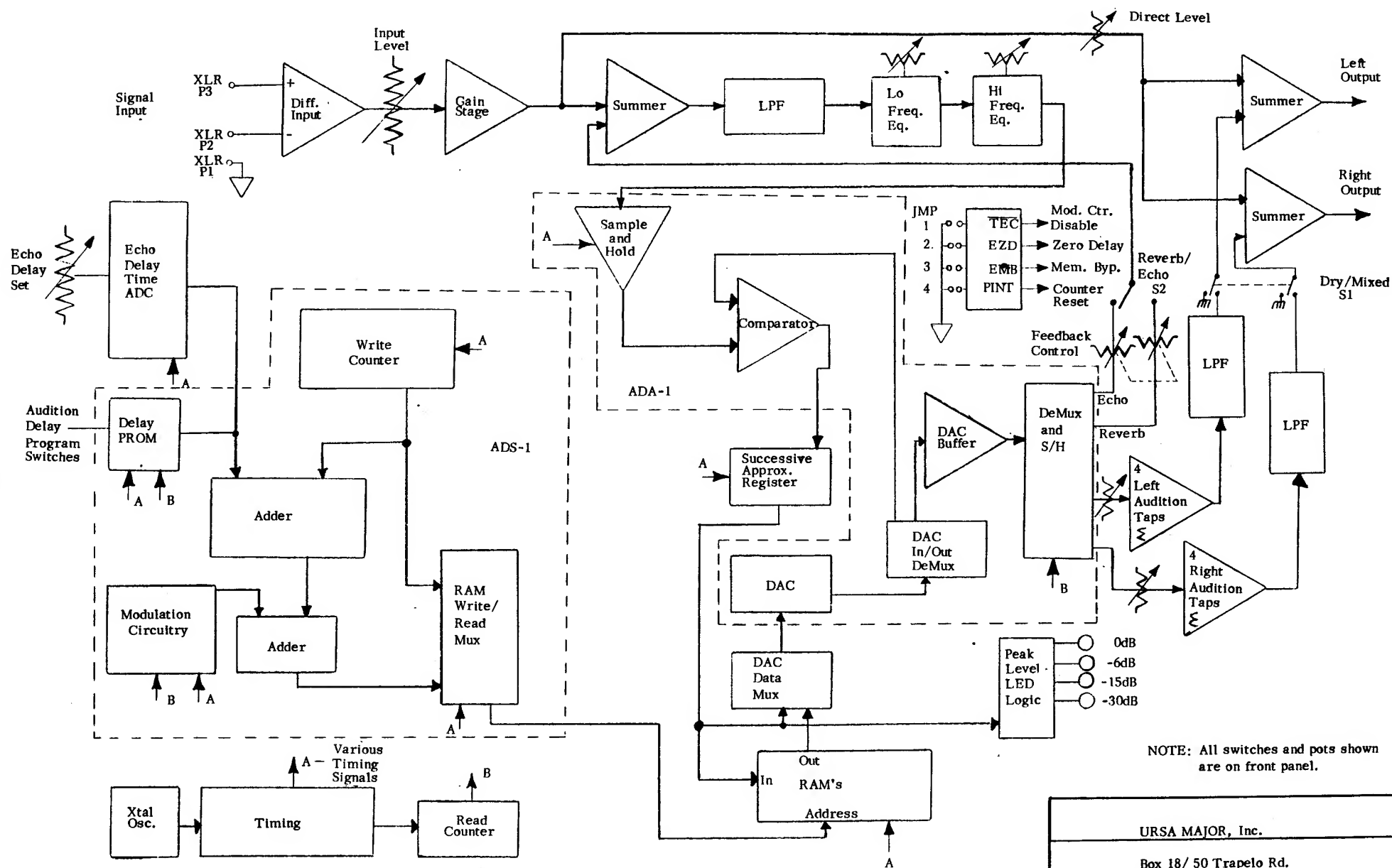
Scope Time Scale: 62.5us/period of ISH

## VI. SCHEMATICS

### VI. A. Note on Schematic Conventions

A word about the convention used in drawing the schematics is in order. On every schematic, a timing signal that leaves that sheet and goes elsewhere is indicated with an arrow for the connector, which is represented by the little triangle-shaped symbol. If the signal is sourced on the module schematic you are looking at, then the arrowhead of the connector symbol points away from the head, indicating that the circuitry on that sheet is the source for that timing signal or other piece of data. If the arrow is coming into the sheet, then the source of the signal is external.

23 a.



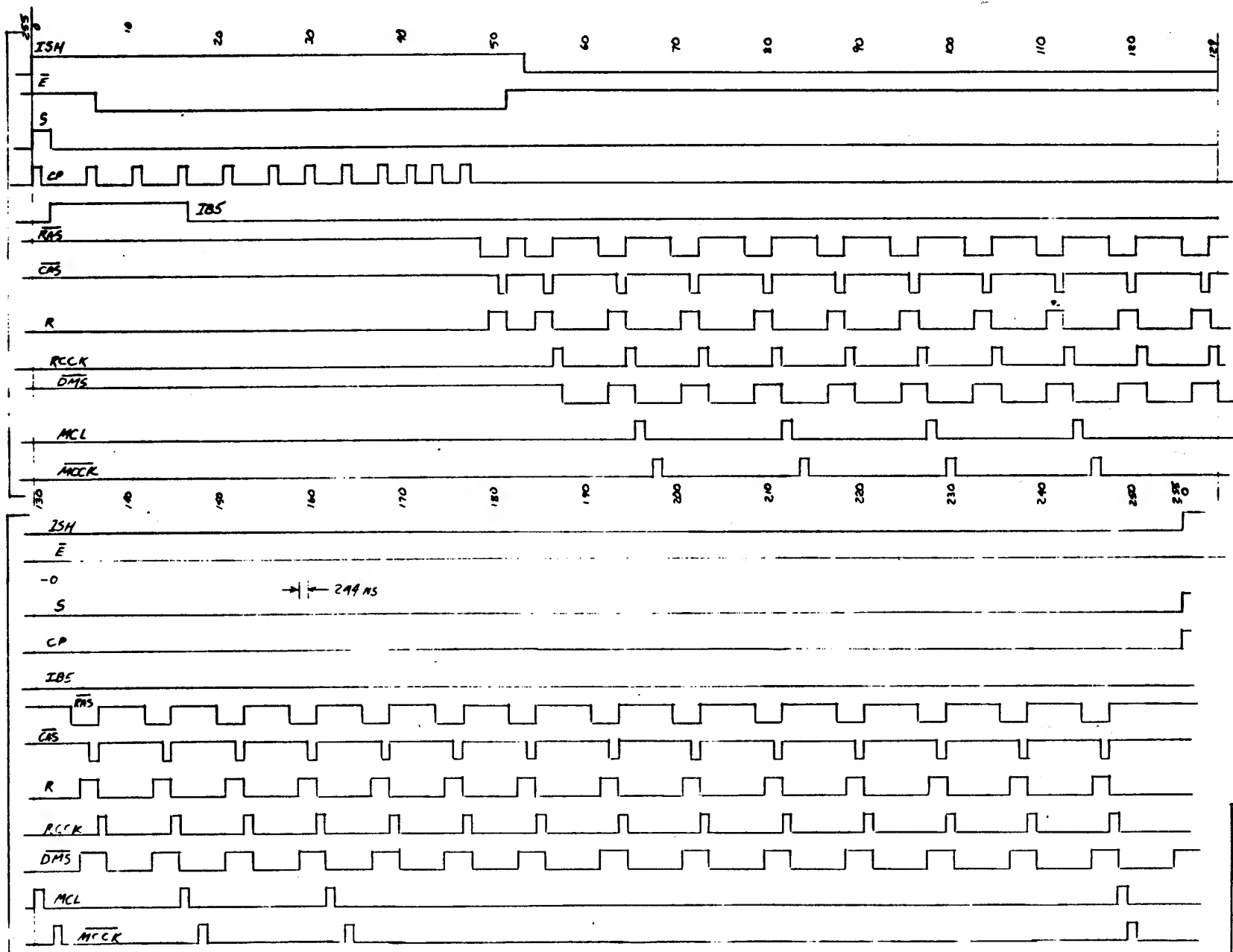
NOTE: All switches and pots shown are on front panel.

URSA MAJOR, Inc.

Box 18/ 50 Trapelo Rd.  
Belmont, MA 02178

Block Diagram SST-282

Drawn: Ron Blomberg 3/31/81



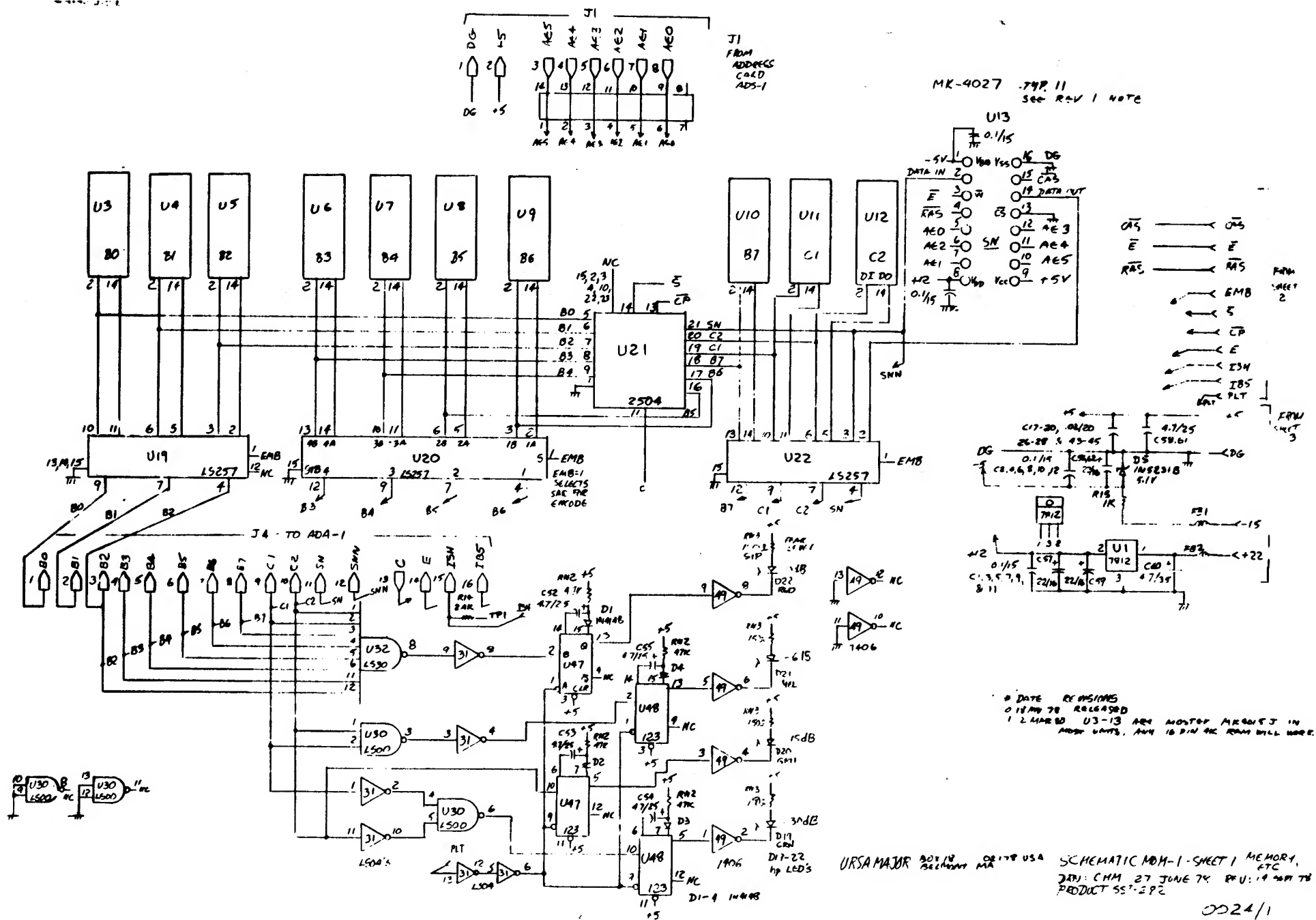
DATE REV  
 3 MAR 79 (REV 1) TO REFLECT  
 EPM 11/11  
 1 24 AUG 79 REVISED TO REFLECT  
 0011/3 - AFTER DELAYED  
 ONE BIT TIME, EACH OF  
 8 PLACES  
 - 5 DEC 79 CP NAME TO CORRECTED -  
 WAS CP  
 2 DEC 79 THE WAS DRAWN HIGH DOWN  
 BT: 150 TO 155 IN ERROR -  
 DEPUINS CORRECTED

UNSA MAJOR, INC.  
 BOX 18  
 BELLEVILLE, MO 64708

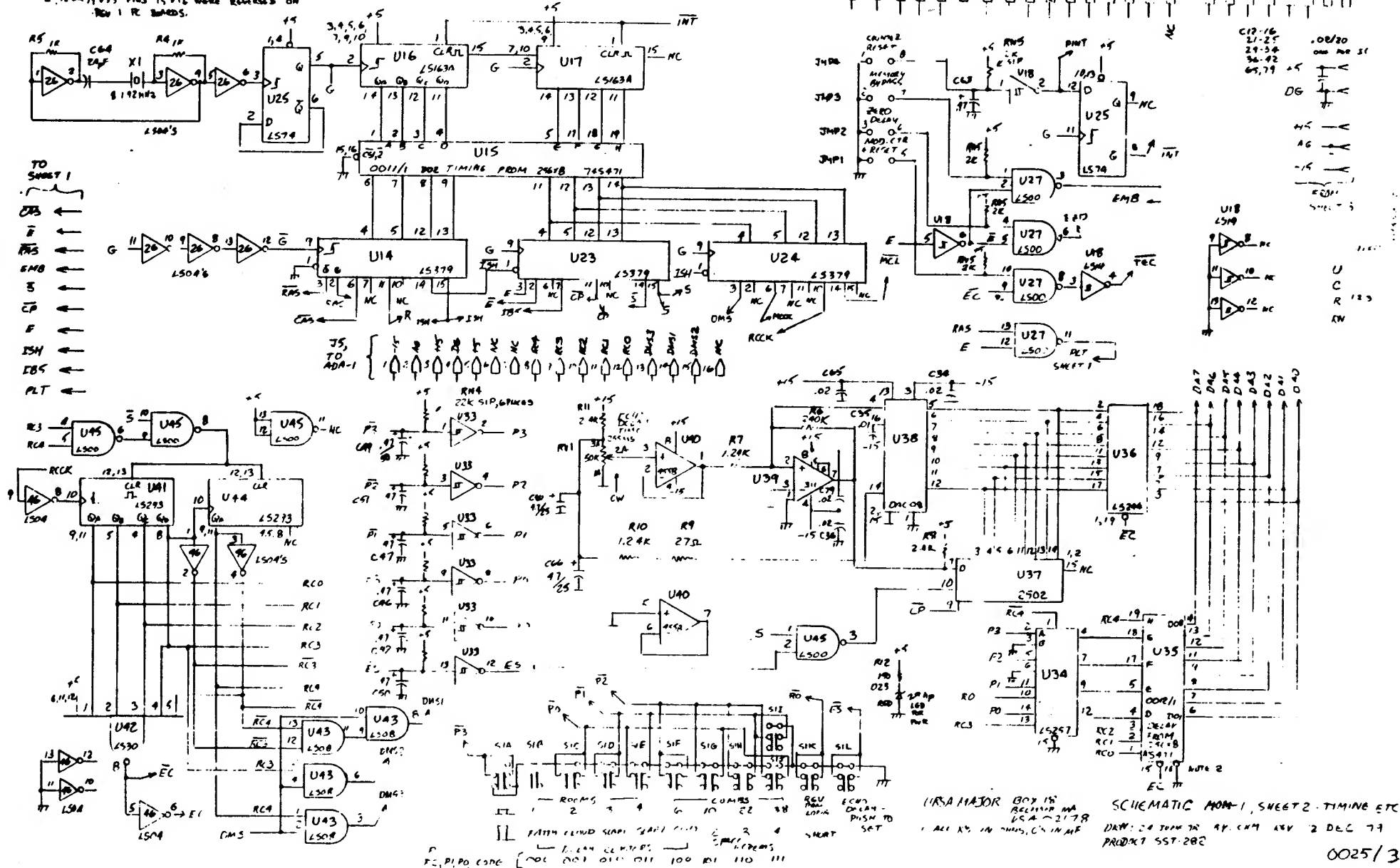
MASTER TIMING DIAGRAM  
 24 APRIL 1979 BY CHM  
 LAST REV DATE: 2 DEC 79  
 REF. PRGM: 0011/1, 0011/3

0284/1

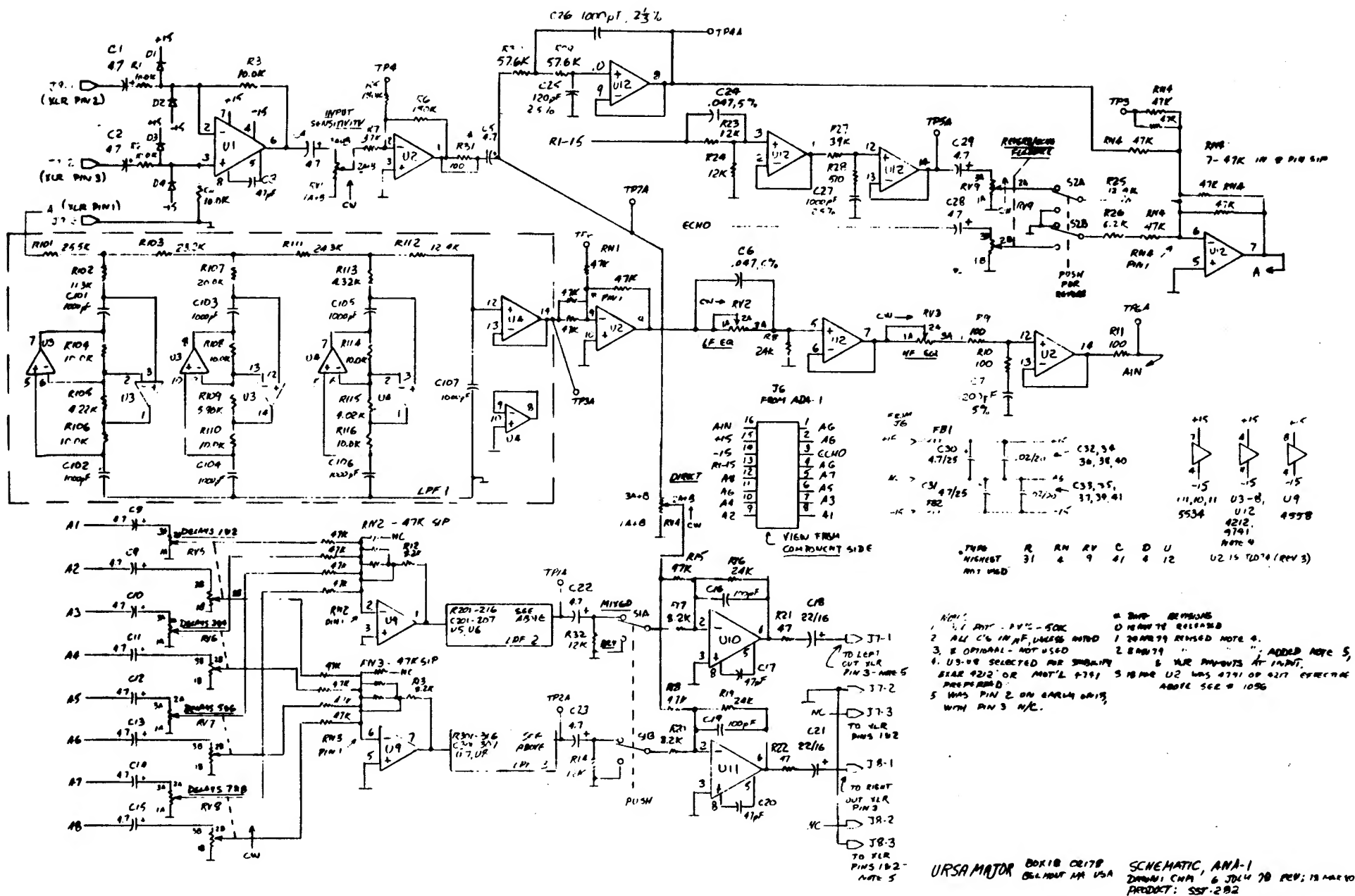




26

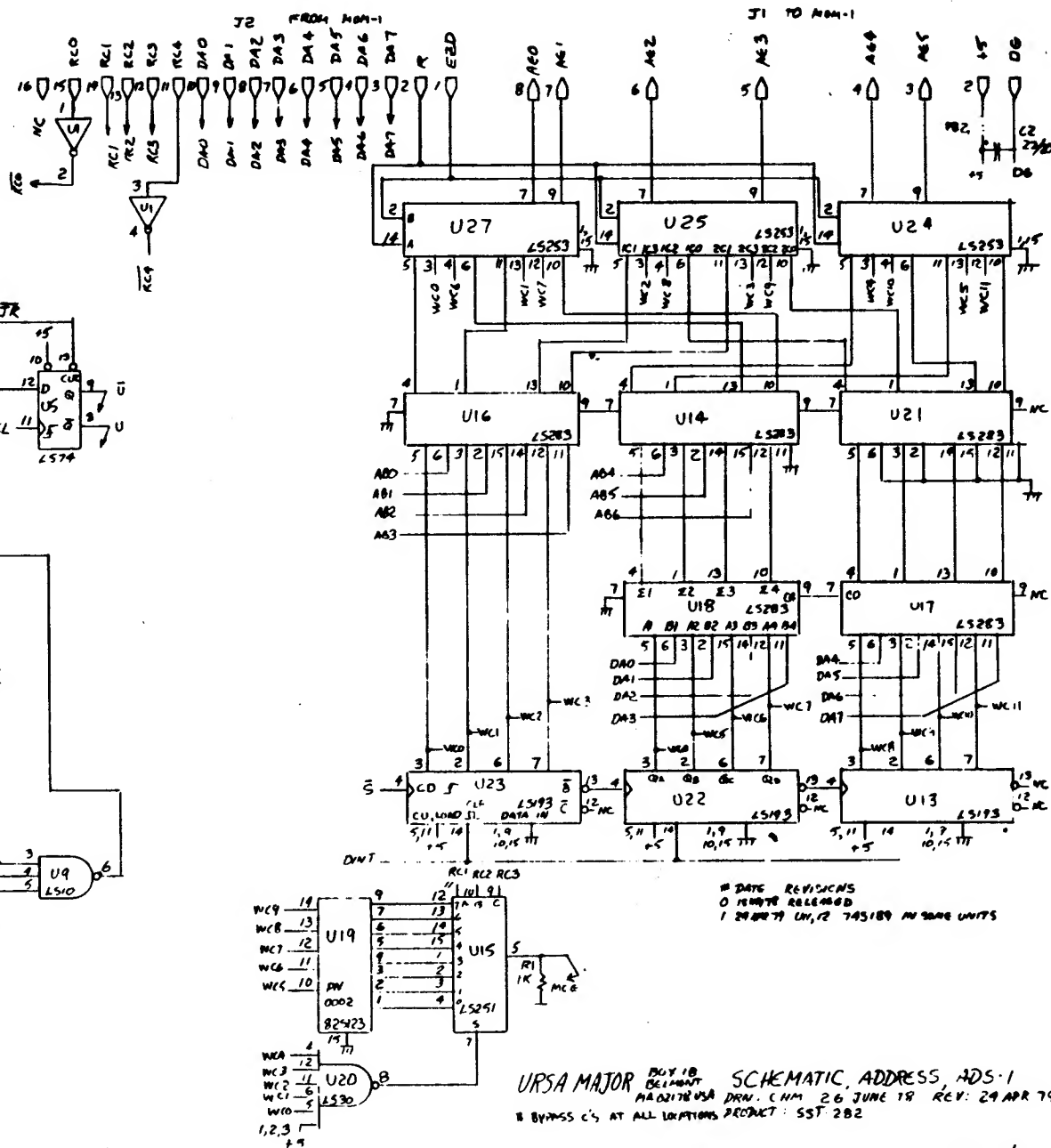






URSA MAJOR BOX 18 021711' SCHEMATIC, ADA-1  
DECLASSIFIED BY 2 DRI: CHM 3 JUL 47K P11J: 24 APR 79  
PRODUCT: SST. 202

0028/1



# VII. PARTS LISTS

## VII. A. Semiconductor Components

<u>PART#</u>	<u>PART</u>	<u>QUANTITY</u>
	IC, DIGITAL	
330-0161	74LS00N	4
330-0209	74LS02N	1
330-0162	74LS04N	4
330-0163	7406N	3
330-0164	74LS08N	1
330-0210	74LS10N	2
330-0165	74LS14N	2
330-0166	74LS30N	3
330-0167	74LS74N	2
330-0270	74LS86N	3
330-0163	74123N	2
330-0169	74LS163N	2
330-0212	74LS189N	2
330-0213	74LS193N	5
330-0170	74LS244N	1
330-0214	74LS251N	1
330-0215	74LS253N	3
330-0171	74LS257N	4
330-0216	74LS283N	5
330-0172	74LS293	2
330-0173	74LS379N	3
330-0174	2502	1
330-0175	2504	1
350-0176	4027 **	11
350-0271	4015 **	11
	IC, MEMORY	
350-0002	74S288-PROGRAMMED 0002/7	1
350-0011	74S471 or TBP 18522-PROGRAMMED 0011/3	1
350-0012	74S471 or TBP 18522-PROGRAMMED 0012/1	1
	IC, LINEAR	
340-0181	7805	1
340-0181	7812	1
340-0182	7815	1
340-0183	7915	1
340-0205	78L05	1
340-0198	5534N	4
340-0207	4741, N **	7
340-0208	4212 **	7
340-0199	1F393	1
340-0179	4558	3
340-0204	TL084 **	7
340-0203	TL074 **	7
	IC, INTERFACE	
345-0020	4051B -USE MOTOROLA ONLY	3
345-0201	4052B	1
345-0202	4053B	1
345-0178	LM311N	2
	IC, CONVERTER	
355-0177	DAC-08- SELECTED	3
	DIODE	
300-0154	1N4148	16(.25
300-0155	1N40041A	10(.25
300-0156	1N5404/MR501	2(.25
	DIODE, ZENER	
300-0157	1N5231B 5.1v 5%	1
300-0158	1N4735A 6.2v	1
300-0159	1N4736A 6.8v	1
300-0160	1N4738A 8.2v	1
	DIODE, LED	
300-0185	GREEN, 5082-4970	2
300-0186	YELLOW, 5082-4970	1
300-0184	RED, 5082-4670	2
	SCR	
3200187	C122-F	1

# VII. B. Passive Components

PART #	203-	PART	QUANTITY	PART #	PART	QUANTITY
		RES.MF, 1% RN55			CAPACITOR,CERAMIC DISC	
0082		953	1	245-0129	47 pF	3
0083		1.0K	3	245-0130	100pF	3
0102		1.24K	2	245-0131	.005/1600v	2
0084		1.43K	1	245-0132	.01/25-50	1
0085		1.58K	1	245-0133	.02/25-50	82
0086		2.26K	1	245-0291	.1/50	14
0269		3.01K	1		BEAD, FERRITE	9
0087		4.02K	3	270-0190	CRYSTAL, 8.192 MHZ	1
0088		4.22K	3	280-0189		
0089		4.32K	3		FUSE	
0090		4.53	1	440-0193	3AG 115v .75A SLO BLO	1
0091		5.11K	1	440-0194	8AG 2.5A/3.0A 361/362	1
0092		5.90K	3	440-0195	3AG 230v/ .375A SLO BLO	1
0093		10.0K	22	451-0045	SWITCH, SLIDE 115/230 SELECT	1
0094		11.3K	3		SWITCH, 16 STATION, PUSHBUTTON	1
0095		12.4K	4		SWITCH, POWER PUSHBUTTON	1
0096		20.0K	3	453-0042	SWITCH, TWO STATION PUSHBUTTON	1
0097		22.1K	1	453-0044		
0098		23.2K	3	453-0078		
0099		24.3K	3		TRANSFORMER, POWER 115/230	1**
0100		25.5K	4	470-0036	TRANSFORMER, POWER 100/200	1**
0280		57.6K	2	470-0254		
	202-	RES CF 1/4W 5%			CONNECTOR	
0103		27	1	490-0257	AC, RECEP, 3 WIRE	1
0104		47	2	490-0243	XLR-3, MALE	2
0105		100	5	490-0247	XLR-3, FEMALE	1
0106		150	1	490-0264	3 PIN BLOCK, FEMALE	3
0107		200	1		8 PIN FEMALE, PC MOUNT	8
0108		22J	3	510-0049	8 PIN MALE PC MOUNT	2
0109		510	2	510-0047	16 PIN MALE PC MOUNT	3
0110		1.0K	4	510-0048	3 PIN, MALE PC MOUNT	3
0111		1.1K	2	510-0046		
0112		2.0K	3		SOCKET	
0113		2.4K	3		DIP 8 PIN	10
0115		4.7K	1	520-0148	DIP 14 PIN	41
0116		6.2K	1	520-0149	DIP 16 PIN	48
0117		8.2K	4	520-0150	DIP 16 PIN EBY-16-9-2	2
0118		10.0K	1	520-0151	DIP 20 PIN	3
0119		12.0K	4	520-0152	DIP 24 PIN	1
0120		24.0K	3	520-0153	TO 220 3 PIN	3
0121		39.0K	2	520-0052		
0122		47.0K	3		BUTTONS	
0123		180.0K	2		RED	3
0124		240.0K	1	550-0299	BLUE	10
	202-	RES CF 1/2W 5%		550-0298	SWITCH CAPS	13
0125		270	1	550-0305		
0126		820	1	600-0192	FUSE CLIP PC MOUNT	4
		RESISTOR VARIABLE			INSULATOR, WASHER	5
200-0118		50K DUAL	10	630-0292	INSULATOR, IC SPREADER	1
201-0206		100ohm AB E4,A,D,J,K	1	630-0293	TERMINAL CRIMP 08-50-01-08	7
		RESISTOR NETWORK		525-0051	TERMINAL CRIMP #16- 02-1105**	3
205-0147		16 PIN DIP 100ohm	1	525-0300		
205-0143		6or 8 PIN SIP 150ohm	1	530-0268	CABLE CLAMP FOR EBY SOCKET	2
205-0144		8 PIN SIP 2.0K	3		TIE WRAP 1/16" - 3/4"	2
205-0145		8 PIN SIP 22.0K	1	530-0272		
205-0146		8 PIN SIP 47.0K	6		CABLE, CLAMP SELF ADHERING	3
		CAPACITORS, ALUMINUM		530-0267	CABLE CLAMP H-H SMITH	1
		ELECTROLYTIC		600-0237		
240-0259		.47/50v	7	541-0253	RUBBER FEET SELF ADHESIVE	6
240-0136		4.7/35v	20		KNOB, BLACK WHITE LINE	
240-0260		330uF/16v	3		21MM	8
240-0261		1000uF/35v	2	550-0284	14.5MM	2
240-0262		4700uF/16v	1	550-0285		
		CAPACITOR TANTILUM-DIPPED			NUT COVER, 14.5MM	
241-0127		4.7uF/25v	15	550-0286	BLACK, WHITE LINE	2
241-0127		4.7uF/35v	1		CAP, 21MM	
241-0128		22uF/16v	10	550-0287	BLUE, WHITE LINE	1
		CAPACITOR MICA		550-0288	RED, WHITE LINE	2
242-0137		24pF DM15 5%	1	550-0289	BLACK, WHITE LINE	1
		CAPACITOR POLYPROPYLENE 2.5%			CAP, 14.5MM	
243-0138		120pF	1	550-0290	BLACK, WHITE LINE	2
243-0140		220pF	24		SPACER, THREADED 4-40 X .375	2
243-0141		1000pF	24	630-0231	SPACER, THREADED 6-32 X .375	2
243-0142		1200pF	1	630-0233	SPACER, THREADED 4-40 X 1.00	3
		CAP,MYLAR		630-0232	INSULATOR, TO 220	3
244-0135		.047/50v	2	630-0282		

\*\* WITH MOLEX #15-04-0703 CONNECTOR, AC RECEPTACLE



<u>PART #</u>	<u>PART</u>	<u>QUANTITY</u>
	SCREW	
640-0217	4-40 X 3/16 PPB	25
640-0218	4-40 X 3/16 PPB	14
640-0219	4-40 X 5/16 FPB 82°	8
640-0224	6-32 X 1/4 PPB	17
640-0225	6-32 X 3/8 FPB 82°	4
640-0226	6-32 X 1/2 PPB	2
640-0229	8-32 X 1/2 PPB	2
	NUT	
643-0221	4-40	3
643-0222	KEPS 4-40	2
643-0227	KEPS 6-32	6
643-0310	HEX 8-32	2
	WASHER	
644-0223	INTERNAL STAR #4	8
644-0228	INTERNAL STAR #6	15
644-0234	WASHER, NYLON SHOULDER #4	3
644-0311	WASHER, SPLIT LOCK #8	2
644-0312	WASHER, #8, STEEL OD.375 ID.174 THK .031	4
670-0191	JUMPER, 22 AWG .5IN, INSUL	
	WIRE	
670-0244	#22 AWG, UL, GREEN,STRAND	3.0IN
670-0246	#22 AWG, UL, BLACK,STRAND	9.0IN
670-0274	#22 AWG, UL, WHITE,STRAND	9.0IN
670-0275	2 CONDUCTOR, SHIELDED	65.IN
680-0252	RIBBON CABLE 922641-16-9-03	1
680-0266	POWER CORD	1
680-0273	SLEEVING, SHRINK 1/4 IN DIA	6IN
700-0019	SST-282 CHASSIS	1
	SST-282	
702-0283	FRONT PANEL	1
702-0018	PANEL SHIELD	1
702-0021	BOTTOMCOVER	1
702-0023	TOP COVER	1
701-0238	BRACKET, KEYSTONE #617	4
701-0281	BRACKET, KEYSTONE #614	9
704-0196	HEAT, SINK, THERMALLOY 6025B-TT	1
	COMPLETE MODULES	
710-0063	ADA-01	1
710-0070	ADS-01	1
710-0076	ANA-01	1